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Detrital zircon and igneous protolith ages of high-grade metamorphic rocks in the Highland and Wanni Complexes, Sri Lanka: Their geochronological correlation with southern India and East Antarctica

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ABSTRACT

The high-grade metamorphic rocks of Sri Lanka place valuable constraints on the assembly of central parts of the Gondwana supercontinent. They are subdivided into the Wanni Complex (WC), Highland Complex (HC) and Vijayan Complex (VC), but their correlation with neighbouring Gondwana terranes is hindered by a poor understanding of the contact between the HC and WC. Laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) U–Pb dating of remnant zircon cores from 45 high-grade metamorphic rocks in Sri Lanka reveals two domains with different age characteristics that correlate with the HC and WC and which help constrain the location of the boundary between them. The HC is dominated by detrital zircon ages of *ca.* 3500–1500 Ma from garnet–biotite gneiss, garnet–cordierite–biotite gneiss, some samples of garnet–orthopyroxene–biotite gneiss and siliceous gneiss (interpreted as paragneisses) and igneous protolith ages of *ca.* 2000–1800 Ma from garnet–hornblende–biotite gneiss, other samples of garnet–orthopyroxene–biotite gneiss, garnet–two-pyroxene granulite, two-pyroxene granulite and charnockite (interpreted as orthogneisses). In contrast, the WC is dominated by detrital zircon ages of *ca.* 1100–700 Ma from paragneisses and igneous protolith ages of *ca.* 1100–800 Ma from orthogneisses. This clearly suggests the HC and WC have different origins, but some of our results and previous data indicate their spatial distribution does not correspond exactly to the unit boundary proposed in earlier studies using Nd model ages. Detrital zircon and igneous protolith ages in the HC suggest that sedimentary protoliths were eroded from local 2000–1800 Ma igneous rocks and an older Paleoproterozoic to Archean craton. In contrast, the WC sedimentary protoliths were mainly eroded from local late Mesoproterozoic to Neoproterozoic igneous rocks with very minor components from an older 2500–1500 Ma craton, and in the case of the WC precursor sediments there was possibly additional detritus derived from early to middle Neoproterozoic metamorphic rocks. The relic zircon core ages in the HC are comparable with those of the Trivandrum Block and Nagercoil Block of southern India. In contrast, those ages in the WC match the Achankovil Shear Zone and Southern Madurai Block of southern India. These comparisons are also supported by Th/U ratios of detrital zircon cores from paragneisses (Th/U ratios of > 0.10 for the former and not only > 0.10 but also ≤ 0.10 for the latter). Comparisons with the Lützow-Holm Complex of East Antarctica indicate that the geochronological characteristics of the HC and WC broadly match those of the Skallen Group, and the Ongul and Okuiwa Groups, respectively.

1. Introduction

Sri Lanka lies within a complex network of late Neoproterozoic mobile belts in Gondwana reconstructions (Fig. 1a and b). These belts are thought to record the assembly of the Gondwana supercontinent, and Sri Lanka can therefore provide important constraints on this amalgamation history. Previous models for Gondwana assembly have been based primarily on correlations of geomorphology, lithology, and ages of metamorphism and post-collisional igneous rocks (e.g. Meert, 2003) (Fig. 1a). There has, however, been increasing use of relic zircon ages from metamorphic rocks to characterise the various pre-metamorphic terranes of Gondwana and their amalgamation history (e.g. Grantham et al., 2008, 2013; Jacobs et al., 2015; Liu et al., 2016) (Fig. 1b), and potential correlations between Sri Lankan metamorphic

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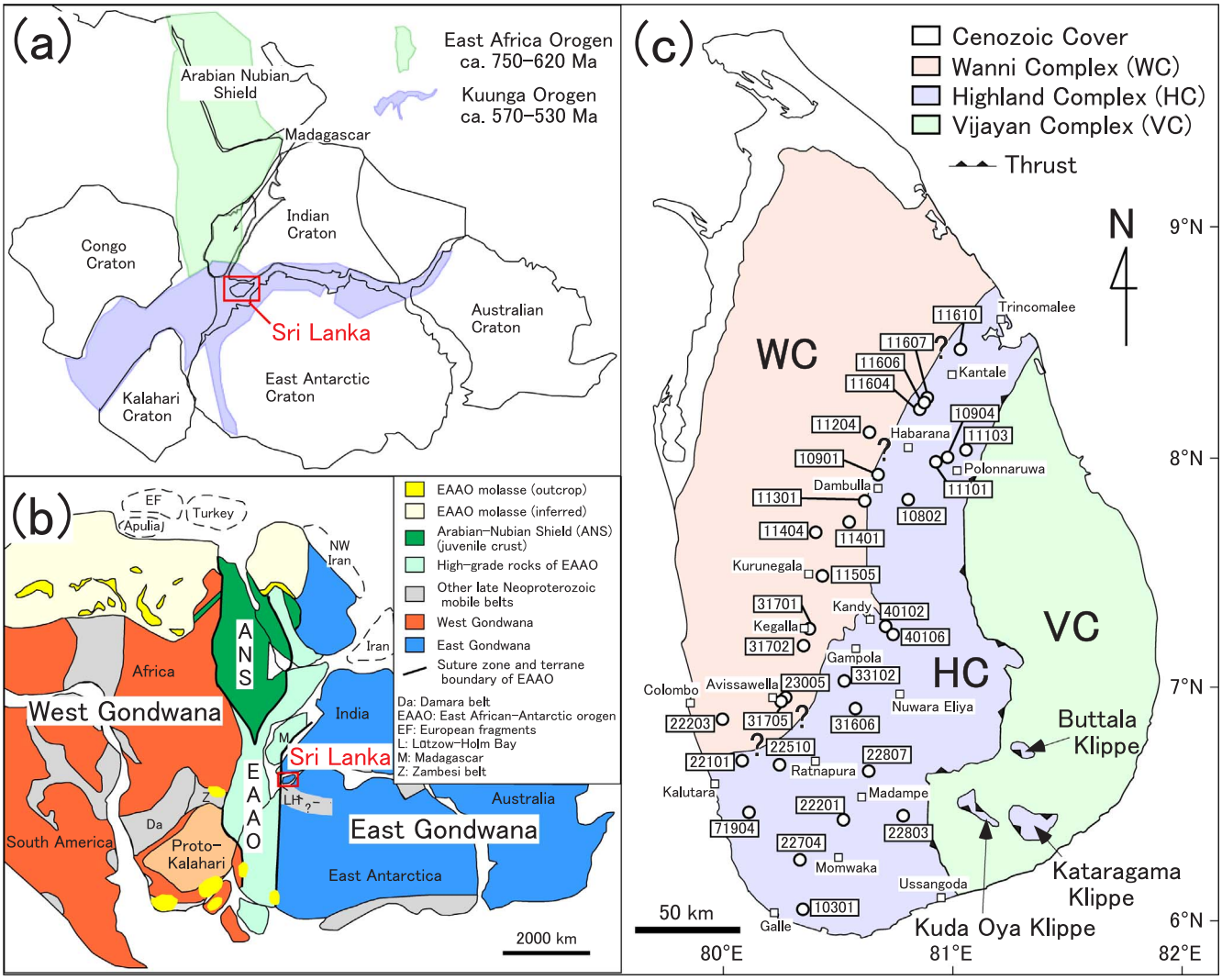

Fig. 1. (a, b) Simplified Gondwana amalgamation models after Meert (2003) (a) and, Jacobs and Thomas (2004) (b). (c) Lithological division of Sri Lanka into the Wanni Complex (WC), Highland Complex (HC) and Vijayan Complex (VC) after Kröner et al. (1991) and Kehelpannala (1997). The sample locations for this study are shown as open circles with location numbers.

rocks and other Gondwana terranes are critical to such studies.

Most of Sri Lanka is composed of high-grade metamorphic rocks that record the history of Gondwana amalgamation and have been the subject of numerous geological, petrological and geochronological studies (e.g. Cooray, 1994 and references therein). These studies have led to the subdivision of Precambrian metamorphic rocks in Sri Lanka into three tectonic blocks, which are the Wanni Complex (WC) in the west, Highland Complex (HC) in the center and Vijayan Complex (VC) in the east (Fig. 1c). Although this division is mainly based on Nd model ages (Milisenda et al., 1988, 1994), the boundary between the VC and HC closely corresponds to a major tectonic thrust contact (e.g. Kleinschrodt, 1994). In contrast, the boundary between the HC and WC does not appear to match the trend of geological structures (Kehelpannala, 2003; Kehelpannala and Ranaweera, 2007; Kröner et al., 2013). It has been suggested that the HC–WC boundary might correspond to several local ductile shear zones (Kleinschrodt and Voll, 1994; Kriegsman, 1994; Tani and Yoshida, 1996; Kehelpannala, 1997, 2003; Tani, 1997; Kehelpannala and Ranaweera, 2007). Recently, Kehelpannala and Ranaweera (2007) attempted to show that the HC–WC boundary is a Neoproterozoic suture zone formed by the collision between the HC and WC, however its precise location remains obscure. Another powerful tool for the lithological subdivision of high-grade metamorphic rocks is the U–Pb age of pre-metamorphic zircon cores which can reveal different origins for samples with similar metamorphic mineral assemblages and structures (e.g. Plavsa et al., 2014). Although previous U–Pb isotope dating has mostly revealed Archean to Paleoproterozoic inheritance in the HC and late Mesoproterozoic to Neoproterozoic inheritance in the WC (Kröner et al., 1987, 1991, 1994, 2003; Baur et al., 1991; Hölzl et al., 1994, Santosh et al., 2014; He et al., 2016a, Takamura et al., 2016), recent studies of pelitic gneisses near the HC–WC boundary but within the HC as defined by Nd model ages have reported zircons with dominantly Neoproterozoic ages (Sajeev et al., 2010; Dharmapriya et al., 2015b, 2016). This complexity suggests that more zircon U–Pb ages are needed to constrain the spatial distribution of Archean to Paleoproterozoic and late Mesoproterozoic to Neoproterozoic inheritance, and help locate the HC–WC boundary more precisely.

In this study, we carried out LA-ICP-MS U–Pb isotope dating to determine the ages of remnant zircon cores in 45 high-grade metamorphic rock samples from Sri Lanka. A spread of sample locations from the northeast to southwest of the island allows us to clarify the geochronological characteristics of the HC and WC and show that their areal distribution is more complex than assumed in previous studies. We also use these zircon core ages to make correlations with formerly adjacent Gondwana terranes in southern India and East Antarctica.